

# (12) UK Patent Application (19) GB (11) 2 393 199 (13) A

(43) Date of Printing by UK Office 24.03.2004

(21) Application No: 0324709.5

(22) Date of Filing: 29.08.2002

(30) Priority Data:

(31) 09949966 (32) 10.09.2001 (33) US

(31) 10132424 (32) 25.04.2002

(86) International Application Data:  
PCT/GB2002/003936 En 29.08.2002

(87) International Publication Data:  
WO2003/023186 En 20.03.2003

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(continued on next page)

(51) INT CL<sup>7</sup>:  
E21B 43/10

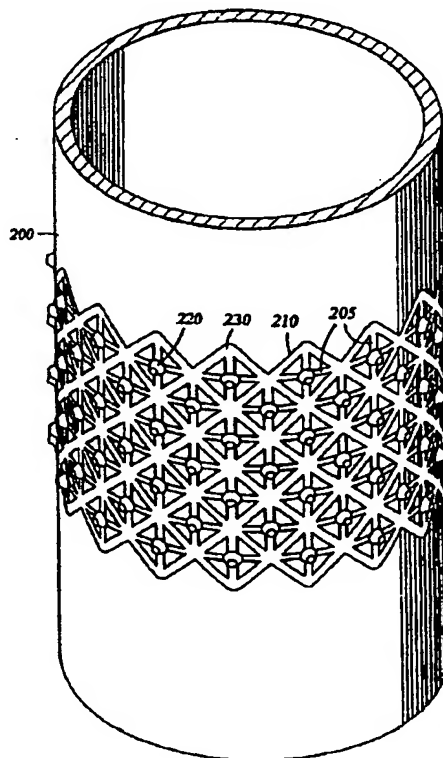
(52) UK CL (Edition W):  
E1F FLA

(56) Documents Cited by ISA:  
GB 2345308 A WO 2000/037766 A2  
US 6189616 B1

(58) Field of Search by ISA:  
INT CL<sup>7</sup> E21B  
Other: EPO-Internal

(54) Abstract Title: An expandable hanger and packer

(57) An apparatus and method of creating a seal between two coaxial tubulars so as to create a hanger and a packer. A first tubular (200) is disposed coaxially within a portion of a second, larger tubular (400). A portion of the first tubular is expanded into frictional contact with the second tubular, thereby creating a liner and a hanger. In one embodiment, a pattern of grooves (210) and profile cuts (205) is formed in the surface of a portion of the first tubular body. The grooves and profile cuts in one aspect define a continuous pattern about the circumference of the tubular body which intersect to form a plurality of substantially identical shapes, such as diamonds. The grooves and profile cuts serve to improve the tensile strength of the tubular body. At the same time, the grooves and profile cuts allow for expansion of the tubular body by use of less radial force. The grooves and profile cuts further provide a gripping means, providing additional frictional support for hanging the expanded tubular onto the inner surface of a surrounding second tubular. Carbide inserts (220) are preferably interdisposed within the pattern of grooves, providing additional gripping means when the smaller diameter tubular body is expanded into the second tubular.



GB 2 393 199

**GB 2393199 A continuation**

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
20 March 2003 (20.03.2003)

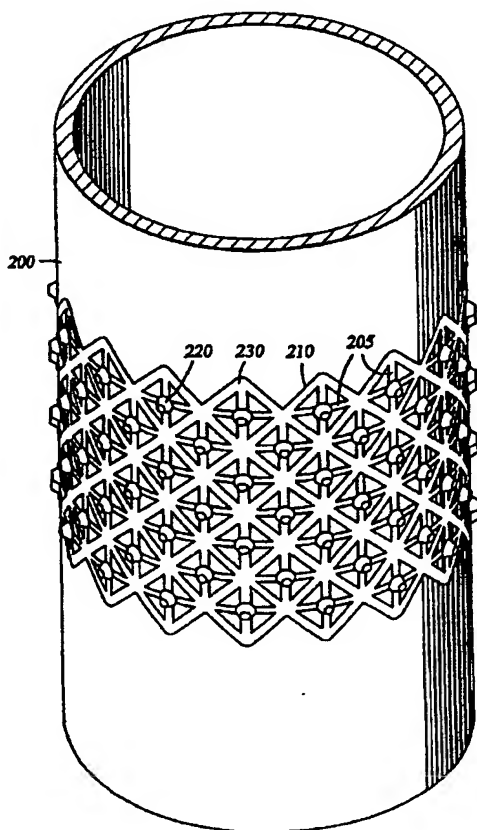
PCT

(10) International Publication Number  
**WO 03/023186 A1**

- (51) International Patent Classification<sup>7</sup>: **E21B 43/10**
- (21) International Application Number: **PCT/GB02/03936**
- (22) International Filing Date: **29 August 2002 (29.08.2002)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:  
09/949,986 10 September 2001 (10.09.2001) US  
10/132,424 25 April 2002 (25.04.2002) US
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- (81) Designated States (national): **AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,**

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(54) Title: **AN EXPANDABLE HANGER AND PACKER**



(57) Abstract: An apparatus and method of creating a seal between two coaxial tubulars so as to create a hanger and a packer. A first tubular (200) is disposed coaxially within a portion of a second, larger tubular (400). A portion of the first tubular is expanded into frictional contact with the second tubular, thereby creating a liner and a hanger. In one embodiment, a pattern of grooves (210) and profile cuts (205) is formed in the surface of a portion of the first tubular body. The grooves and profile cuts in one aspect define a continuous pattern about the circumference of the tubular body which intersect to form a plurality of substantially identical shapes, such as diamonds. The grooves and profile cuts serve to improve the tensile strength of the tubular body. At the same time, the grooves and profile cuts allow for expansion of the tubular body by use of less radial force. The grooves and profile cuts further provide a gripping means, providing additional frictional support for hanging the expanded tubular onto the inner surface of a surrounding second tubular. Carbide inserts (220) are preferably inter-disposed within the pattern of grooves, providing additional gripping means when the smaller diameter tubular body is expanded into the second tubular.

WO 03/023186 A1



GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— with international search report

(84) **Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## AN EXPANDABLE HANGER AND PACKER

The present invention relates to wellbore completion. More particularly, the invention relates to an apparatus and method for creating an attachment and a seal between two  
5 tubulars in a wellbore.

In the drilling of oil and gas wells, a wellbore is formed using a drill bit that is urged downwardly at a lower end of a drill string. After drilling a predetermined depth, the drill string and bit are removed, and the wellbore is lined with a string of steel pipe  
10 called casing. The casing provides support to the wellbore and facilitates the isolation of certain areas of the wellbore adjacent hydrocarbon bearing formations. The casing typically extends down the wellbore from the surface of the well to a designated depth. An annular area is thus defined between the outside of the casing and the earth formation. This annular area is filled with cement to permanently set the casing in the  
15 wellbore and to facilitate the isolation of production zones and fluids at different depths within the wellbore.

It is common to employ more than one string of casing in a wellbore. In this respect, a first string of casing is set in the wellbore when the well is drilled to a first designated  
20 depth. The well is then drilled to a second designated depth, and a second string of casing, or liner, is run into the well to a depth whereby the upper portion of the second liner is overlapping the lower portion of the first string of casing. The second liner string is then fixed or hung in the wellbore, usually by some mechanical slip mechanism well-known in the art, and cemented. This process is typically repeated with additional  
25 casing strings until the well has been drilled to total depth.

After the initial string of casing is set, the wellbore is drilled to a new depth. An additional string of casing, or liner, is then run into the well to a depth whereby the upper portion of the liner, is overlapping the lower portion of the surface casing. The  
30 liner string is then fixed or hung in the wellbore, usually by some mechanical slip mechanism well known in the art, commonly referred to as a hanger.

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Downhole tools with sealing elements are placed within the wellbore to isolate areas of the wellbore fluid or to manage production fluid flow from the well. These tools, such as plugs or packers, for example, are usually constructed of cast iron, aluminium or other alloyed metals and include slip and sealing means. The slip means fixes the tool in the wellbore and typically includes slip members and cores to wedgingly attach the tool to the casing well. In addition to slip means, conventional packers include a synthetic sealing element located between upper and lower metallic retaining rings.

The sealing element is set when the rings move towards each other and compress the element there between, causing it to expand outwards into an annular area to be sealed and against an adjacent tubular or wellbore. Packers are typically used to seal an annular area formed between two coaxially disposed tubulars within a wellbore. For example, packers may seal an annulus formed between production tubing disposed within wellbore casing. Alternatively, packers may seal an annulus between the outside of the tubular and an unlined borehole. Routine uses of packers include the protection of casing from pressure, both well and stimulation pressures, as well as the protection of the wellbore casing from corrosive fluids. Other common uses include the isolation of formations or leaks within a wellbore casing or multiple production zones, thereby preventing the migration of fluid between zones. Packers may also be used to hold fluids or treating fluids within the casing annulus in the case of formation treatment, for example.

One problem associated with conventional sealing and slip systems of conventional downhole tools relates to the relative movement of the parts necessary in order to set the tools in a wellbore. Because the slip and sealing means require parts of the tool to be moved in opposing directions, a run-in tool or other mechanical device must necessarily run into the wellbore with the tool to create the movement. Additionally, the slip means takes up valuable annular space in the wellbore. Also, the body of a packer necessarily requires wellbore space and reduces the bore diameter available for production tubing, etc.

A recent trend in well completion has been the advent of expandable tubular technology. It has been discovered that both slotted and solid tubulars can be expanded *in situ* so as to enlarge the inner diameter. This, in turn, enlarges the path through which both fluid and downhole tools may travel. Also, expansion technology enables a smaller tubular to be run into a larger tubular, and then expanded so that a portion of the smaller tubular is in contact with the larger tubular therearound. Tubulars are expanded by the use of a cone-shaped mandrel or by an expander tool with expandable, fluid actuated members disposed on a body and run into the wellbore on a tubular string.

During expansion of a tubular, the tubular walls are expanded past their elastic limit. Examples of expandable tubulars include slotted screen, joints, packers, and liners. The use of expandable tubulars as hangers and packers allows for the use of larger diameter production tubing, because the conventional slip mechanism and sealing mechanism are eliminated.

While expanding tubulars in a wellbore offers obvious advantages, there are problems associated with using the technology to create a hanger or packer through the expansion of one tubular into another. By plastically deforming the tubular, the cross-sectional thickness of the tubular is necessarily reduced. Simply increasing the initial cross-sectional thickness of the tubular to compensate for the reduced tensile strength after expansion results in an increase in the amount of force needed to expand the tubular.

More importantly, when compared to a conventional hanger, an expanded tubular with no gripping structure on the outer surface has a reduced capacity to support the weight of a liner. This is due to a reduced coefficient of friction of the outer surface of an expandable tubular in comparison to the slip mechanism having teeth or other gripping surfaces formed thereon. In another problem, the expansion of the tubular in the wellbore results in an ineffective seal between the expanded tubular and the surrounding wellbore.

A need therefore exists for an expandable tubular connection with increased strength. There is a further need for an expandable tubular connection providing an improved gripping surface between an expanded tubular and an inner wall of a surrounding tubular. Yet a further need exists for an expandable tubular configured to allow metal  
5 flow upon expansion to insure contact and sealing capabilities between an expanded tubular and an inner wall of a surrounding tubular. There is yet a further need for an expandable tubular with an increased capacity to support the weight of a liner.

In accordance with a first aspect of the present invention there is provided an apparatus  
10 for engaging a first tubular and a second tubular in a wellbore, the apparatus comprising:

a tubular body formed on the first tubular, having an inner surface and an outer surface, said tubular body being expandable radially outward into contact with an inner wall of the second tubular by the application of an outwardly directed force supplied to  
15 the inner surface of said tubular body; and

gripping means formed on the outer surface of said tubular body for increasing friction between the first and second tubulars upon expansion of said tubular body.

Further aspects and preferred features are set out in claims 2 *et seq.*  
20

At least in preferred embodiments, the present invention provides a tubular body formed on a portion of a first tubular. The tubular body is expanded so that the outer surface of the tubular body is in frictional contact with the inner surface of a surrounding second tubular. In one embodiment, the tubular body is modified by machining grooves and  
25 profile cuts into the surface, thereby reducing the amount of radial force required to expand the tubular body on the first tubular into the surrounding tubular.

The tubular body optionally includes hardened inserts, such as carbide buttons, for gripping the surrounding tubular upon contact. The gripping mechanism increases the  
30 capacity of the expanded tubular to support its weight and to serve as a hanger. In another aspect, the outer surface of the expandable tubular body optionally includes a



pliable material such as an elastomer within grooves and profile cuts formed on the outer surface of the tubular for increasing the sealing capability of the expandable tubular. As the tubular is expanded, metal flow causes the profile cuts to close up, thereby causing the pliable material to extrude outward. This extrusion of the pliable material insures contact with the casing and improves the sealing characteristics of the interface between the expanded tubular and the casing.

Some preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

10

Figure 1 is a perspective view of a tubular having profile cuts that intersect corners of the grooves formed in the outer surface, and having inserts of a hardened material also disposed around the outer surface;

15 Figure 2 is a section view of the tubular of Figure 1;

Figure 3 is an exploded view of an exemplary expander tool;

20 Figure 4 is a partial section view of a tubular of the present invention within a wellbore, and showing an expander tool attached to a working string also disposed within the tubular;

Figure 5 is a partial section view of the tubular of Figure 4 partially expanded by the expander tool; and

25 Figure 6 is a partial section view of an expanded tubular in the wellbore with the expander tool and working string removed.

Figure 1 is a perspective view of the apparatus of the present invention. The apparatus 200 defines a tubular body formed on a portion of a larger tubular. The tubular body 200 shown in Figure 1 includes a series of relief grooves 210 and profile cuts 205 machined into the outer surface. However, it is within the scope of the present

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invention to machine some or all of the grooves 210 into the inner surface of the expandable tubular 200. The relief grooves 210 and profile cuts 205 serve to reduce the thickness of the tubular 200, thereby reducing the amount of material that must be plastically deformed in order to expand the tubular 200. This reduction in material also  
5 results in a reduction in the amount of force needed to expand the tubular 200.

As shown in Figure 1, the grooves 210 are machined in a defined pattern. Employment of a pattern of grooves 210 serves to increase the tensile properties of the tubular 200 beyond those of a tubular with straight grooves simply cut around the circumference of  
10 the tubular. This improvement in tensile properties is due to the fact that the variation in cross-sectional thickness will help to prevent the propagation of any cracks formed in the tubular. The pattern of grooves depicted in Figure 1 is a continuous pattern of grooves 210 about the circumference of the body 200, with the grooves 210 intersecting to form a plurality of substantially identical shapes. In the preferred embodiment, the  
15 shapes are diamonds. However, the scope of this invention is amenable to other shapes, including but not limited to polygonal shapes, and interlocking circles, loops or ovals (not shown).

In one embodiment, the profile cuts 205 are formed on the surface of the shapes created  
20 by the grooves 210. The profile cuts 205 are formed at a predetermined depth less than the grooves 210 so that the profile cuts 205 will not substantially affect the compressive or tension capabilities of the tubular 200 upon expansion. The profile cuts 205 may be horizontal cuts, vertical cuts or combinations thereof to divide each shape into two or more portions. Preferably, the profile cuts 205 intersect the corners of the grooves 210  
25 as depicted in Figure 1.

Figure 1 also depicts inserts 220 interdisposed within the pattern of grooves 210 and profile cuts 205. The inserts 220 provide a gripping means between the outer surface of the tubular 200 and the inner surface of a larger diameter tubular (not shown) within  
30 which the tubular 200 is coaxially disposed. The inserts 220 are made of a suitably hardened material, and are attached to the outer surface of the tubular 200 through a

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suitable means such as soldering, epoxying or other adhesive method, or via threaded connection. In the preferred embodiment, carbide inserts 220 are press-fitted into preformed apertures in the outer surface of tubular body 200. After expansion, the inserts 220 are engaged with the inner surface of a larger diameter tubular (not shown),  
5 thereby increasing the ability of the expanded tubular 200 to support the weight of the tubular below the expanded portion.

In the embodiment shown in Figure 1, carbide inserts 220 are utilized as the gripping means. However, other materials may be used for fabrication of the inserts 220 so long  
10 as the inserts 220 are sufficiently hard to be able to grip the inner surface of an outer tubular during expansion of the tubular body 200. Examples of fabrication materials for the inserts 220 include ceramic materials (such as carbide) and hardened metal alloy materials. The carbide inserts 220 define raised members fabricated into the tubular body 200. However, other embodiments of gripping means may alternatively be  
15 employed. Such means include but are not limited to buttons having teeth (not shown), or other raised or serrated members on the outer surface of the expandable tubular 200. Alternatively, the gripping means may define a plurality of hardened tooth patterns added to the outer surface of the tubular body 200 between the grooves 210 themselves.

20 The embodiment of Figure 1 also depicts a pliable material 230 disposed within the grooves 210 and profile cuts 205. The pliable material 230 increases the ability of the tubular 200 to seal against an inner surface of a larger diameter tubular upon expansion. In the preferred embodiment, the pliable member 230 is fabricated from an elastomeric material. However, other materials are suitable which enhance the fluid seal sought to  
25 be obtained between the expanded portion of tubular 200 and an outer tubular, such as surface casing (not shown). The pliable material 230 is disposed within the grooves 210 and profile cuts 205 by a thermal process, or some other well known means. A thin layer of the pliable material 230 may also encapsulate the inserts 220 and facilitate the attachment of the inserts 220 to the tubular 200.

Figure 2 is a section view of a portion of the tubular 200 of Figure 1. In this view, the inserts 220 are shown attached to the tubular 200 in the areas between the grooves 210 and at an intersection of the profile cuts 205. In this respect, the inserts 220 are interdispersed within the pattern of grooves 210 and profile cuts 205. Figure 2 also  
5 clearly shows the reduction in cross-sectional thickness of the tubular 200 created by the grooves 210 and profile cuts 205 before expansion. Figure 2 further shows the profile cuts 205 formed at a depth less than the grooves 210.

The inserts 220 in Figure 2 have a somewhat conical shape projecting from the outer  
10 surface of the tubular 200 to assist in engagement of the inserts 200 into an outer tubular (shown in Figure 4). For clarity, the inserts are exaggerated in the distance they extend from the surface of the tubular. In one embodiment, the inserts extend only about 0.03 inches (0.8 mm) outward prior to expansion. In another embodiment, the raised  
15 members 220 are initially recessed, either partially or completely, with respect to the tubular 200, and then extend at least partially outward into contact with the casing after expansion. Such an embodiment is feasible for the reason that the wall thickness of the tubular 200 becomes thinned during the expansion process, thereby exposing an otherwise recessed raised member.

20 The tubular body 200 of the present invention is expanded by an expander tool 100 acting outwardly against the inside surface of the tubular 200. Figure 3 is an exploded view of an exemplary expander tool 100 for expanding the tubular 200. The expander tool 100 has a body 102, which is hollow and generally tubular with connectors 104 and 106 for connection to other components (not shown) of a downhole assembly. The  
25 connectors 104 and 106 are of a reduced diameter compared to the outside diameter of the longitudinally central body part of the tool 100. The central body part 102 of the expander tool 100 shown in Figure 3 has three recesses 114, each holding a respective roller 116. Each of the recesses 114 has parallel sides and extends radially from a radially perforated tubular core (not shown) of the tool 100. Each of the mutually  
30 identical rollers 116 is somewhat cylindrical and barrelled. Each of the rollers 116 is mounted by means of an axle 118 at each end of the respective roller 116 and the axles

are mounted in slidable pistons 120. The rollers 116 are arranged for rotation about a respective rotational axis that is parallel to the longitudinal axis of the tool 100 and radially offset therefrom at 120-degree mutual circumferential separations around the central body 102. The axles 118 are formed as integral end members of the rollers 116, with the pistons 120 being radially slidable, one piston 120 being slidably sealed within each radially extended recess 114. The inner end of each piston 120 is exposed to the pressure of fluid within the hollow core of the tool 100 by way of the radial perforations in the tubular core. In this manner, pressurized fluid provided from the surface of the well, via a working string 310, can actuate the pistons 120 and cause them to extend outward whereby the rollers 116 contact the inner wall of a tubular 200 to be expanded.

Figure 4 is a partial section view of a tubular 200 of the present invention in a wellbore 300. The tubular 200 is disposed coaxially within the casing 400. An expander tool 100 attached to a working string 310 is visible within the tubular 200. Preferably, the tubular 200 is run into the wellbore 300 with the expander tool 100 disposed therein. The working string 310 extends below the expander tool 100 to facilitate cementing of the tubular 200 in the wellbore 300 prior to expansion of the tubular 200 into the casing 400. A remote connection (not shown) between the working, or run-in, string 310 and the tubular 200 temporarily connects the tubular 200 to the run-in string 310 and supports the weight of the tubular 200. In one embodiment of the present invention, the temporary connection is a collet (not shown), and the tubular 200 is a string of casing.

Figure 4 depicts the expander tool 100 with the rollers 116 retracted, so that the expander tool 100 may be easily moved within the tubular 200 and placed in the desired location for expansion of the tubular 200. Hydraulic fluid (not shown) is pumped from the surface to the expander tool 100 through the working string 310. When the expander tool 100 has been located at the desired depth, hydraulic pressure is used to actuate the pistons (not shown) and to extend the rollers 116 so that they may contact the inner surface of the tubular 200, thereby expanding the tubular 200.

Figure 4 also shows the carbide inserts 220 attached to the outer surface of the tubular 200. Because the tubular 200 has not yet been expanded, the carbide inserts 220 are not in contact with the casing 400 so as to form a grip between the tubular 200 and casing 400. Figure 4 also shows the pliable material 230 disposed within the grooves 210 and the profile cuts 205.

Figure 5 is a partial section view of the tubular 200 partially expanded by the expander tool 100. At a predetermined pressure, the pistons (not shown) in the expander tool 100 are actuated and the rollers 116 are extended until they contact the inside surface of the tubular 200. The rollers 116 of the expander tool 100 are further extended until the rollers 116 plastically deform the tubular 200 into a state of permanent expansion. The working string 310 and the expander tool 100 are rotated during the expansion process, and the tubular 200 is expanded until the tubular's outer surface contacts the inner surface of the casing 400. As the tubular 200 contacts the casing 400, the inserts 220 begin to engage the inner surface of the casing 400.

The grooves 210 are also expanded during this expansion process, thereby causing some of the metal around the grooves 210 to flow away from the grooves 210. The metal flow is redistributed in the shallower profile cuts 205, thereby closing the profile cuts 205. As the profile cuts 205 close, the pliable material 230 in the profile cuts 205 extrudes outward into contact with the casing 400. Further, the pliable material 230 in the grooves 210 fills a space remaining between the grooves 210 and the casing 400. After the pliable material 230 contacts the casing 400, the interface between the expanded tubular 200 and the casing 400 is sealed. The working string 310 and expander tool 100 are then translated within the tubular 200 until the desired length of the tubular 200 has been expanded.

Figure 6 is a partial section view of an expanded tubular 200 in a wellbore 300, with the expander tool 100 and working string 310 removed. Figure 6 depicts the completed expansion process, after which the expanded portion of the tubular 200 defines both a packer and a hanger. As a packer, the expanded portion of the tubular 200 seals the

annular area between the casing 400 and the tubular 200. As a hanger, the expanded portion of the tubular 200 supports the weight of the tubular 200.

Figure 6 shows the engagement between the inserts 220 and the inner surface of the casing 400. The engagement enables the expanded portion of the tubular 200 to support an increased weight in comparison to an expanded tubular without inserts. The inserts 220 axially and rotationally fix the outer surface of the expanded tubular 200 to the inner surface of the casing 400. Further, the profile cuts 205 are closed and the pliable material 230 that was in the profile cuts 205 and the grooves 210 is disposed in the interface between the expanded tubular 200 and the casing 400.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be directed without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

**CLAIMS:**

1. An apparatus for engaging a first tubular and a second tubular in a wellbore, the apparatus comprising:
    - 5 a tubular body formed on the first tubular, having an inner surface and an outer surface, said tubular body being expandable radially outward into contact with an inner wall of the second tubular by the application of an outwardly directed force supplied to the inner surface of said tubular body; and
    - gripping means formed on the outer surface of said tubular body for increasing
    - 10 friction between the first and second tubulars upon expansion of said tubular body.
  2. An apparatus as claimed in claim 1, wherein said gripping means defines at least one raised member.
  - 15 3. An apparatus as claimed in claim 2, wherein said at least one raised member defines a plurality of inserts.
  4. An apparatus as claimed in claim 3 wherein said inserts are press-fitted into preformed apertures in the outer surface of said tubular body.
  - 20 5. An apparatus as claimed in claim 3 or 4, wherein said plurality of inserts are fabricated from a hardened metal alloy.
  6. An apparatus as claimed in claim 3 or 4, wherein said plurality of inserts are
  - 25 fabricated from a ceramic material.
  7. An apparatus as claimed in claim 2, wherein said at least one raised member defines a plurality of buttons having teeth.
  - 30 8. An apparatus as claimed in any preceding claim, wherein said gripping means includes grooves formed in the outer surface of said tubular body.
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9. An apparatus for engaging a first tubular and a second tubular in a wellbore, the apparatus comprising:

5 a tubular body formed on the first tubular, having an inner surface and an outer surface, said tubular body being expandable radially outward into contact with an inner wall of the second tubular by the application of an outwardly directed force supplied to the inner surface of said tubular body; and

grooves formed in a surface of said tubular body.

10 10. An apparatus as claimed in claim 9, wherein said grooves are formed in the outer surface of said tubular body.

11. An apparatus as claimed in claim 9 or 10, further comprising gripping means formed on the outer surface of the tubular body for further increasing friction between  
15 the first and second tubulars upon expansion of the tubular body.

12 An apparatus as claimed in claim 11, wherein the gripping means define raised members extending outward from the outer surface of the body.

20 13. An apparatus as claimed in any of claims 8 to 12, wherein said grooves are formed in a pattern.

14. An apparatus as claimed in claim 13 when appended directly or indirectly to claim 2 or claim 12, wherein said raised members define inserts interdisposed in the  
25 pattern of said grooves.

15. An apparatus as claimed in claim 13 or 14, wherein the pattern of said grooves is a continuous pattern about the circumference of the body, the grooves intersecting to form a plurality of substantially identical shapes.

16. An apparatus as claimed in claim 15, wherein said substantially identical shapes are diamonds.
17. An apparatus as claimed in any of claims 8 to 16, wherein said grooves are  
5 substantially filled with a pliable material.
18. An apparatus as claimed in any of claims 8 to 17, wherein grooves are formed on the outer surface or inner surface of the tubular body or combinations thereof.
- 10 19. An apparatus as claimed in any of claims 8 to 18, further comprising at least one profile cut formed in the outer surface of the body.
20. An apparatus as claimed in claim 18, wherein the at least one profile cut is constructed and arranged to close upon expansion of the tubular body.
- 15 21. An apparatus as claimed in claim 19 or 20, wherein the at least one profile cut is formed at a depth less than a depth of the grooves.
22. An apparatus as claimed in claim 19, 20 or 21, wherein the at least one profile  
20 cut is substantially filled with a pliable material.
23. An apparatus as claimed in any of claims 19 to 22, comprising a plurality of profile cuts intersecting the grooves.
- 25 24. An apparatus as claimed in claim 23, wherein the plurality of grooves and the plurality of profile cuts are formed in a pattern.
25. An apparatus as claimed in any of claims 19 to 22 when appended directly or indirectly to claim 15, wherein the at least one profile cut is formed on the surface of the  
30 plurality of substantially identical shapes, whereby the at least one profile cut intersects the grooves.
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26. An apparatus as claimed in any preceding claim, wherein each of the first and the second tubulars is a string of casing.

- 5 27. A method of completing a wellbore comprising the steps of:  
providing a first tubular, said first tubular having a pattern of grooves on an  
outer surface of a portion thereof;  
positioning a second tubular within a wellbore  
positioning said first tubular coaxially within a portion of said second tubular,  
10 said second tubular having an inner diameter which is larger than the outer diameter of  
said first tubular;  
positioning an expander tool within said first tubular at a depth proximate the  
pattern of said grooves; and  
activating said expander tool so as to apply a force to the inner surface of said  
15 first tubular, thereby expanding said first tubular such that the outer surface of said first  
tubular is in frictional contact with the inner surface of said second tubular;

28. A method as claimed in claim 27, wherein said grooves are disposed in a  
continuous pattern about the circumference of said first tubular body, said grooves  
20 intersecting to form a plurality of substantially identical shapes.

29. A method as claimed in claim 28, wherein said substantially identical shapes are  
diamonds.

- 25 30. A method as claimed in claim 27, 28 or 29, wherein  
said grooves are substantially filled with a pliable material; and  
wherein said step of activating of said expander tool is accomplished by  
applying hydraulic force to a plurality of roller members disposed radially about the  
expander tool.

31. A method as claimed in any of claims 27 to 30, wherein the first tubular further comprises a plurality of profile cuts disposed about the circumference of the first tubular body, formed at a depth less than the grooves.

5 32. A method as claimed in claim 13, wherein the profile cuts are filled with pliable material.

33. A method as claimed in claim 31 or 32, wherein, as the first tubular is expanded, the profile cuts close.

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34. A method as claimed in any of claims 27 to 33, further comprising the step of positioning gripping means on the outer surface of said tubular body interspersed between said grooves for further increasing friction between the first and second tubulars upon expansion of said first tubular.

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35. A method as claimed in claim 34, wherein said gripping means defines a plurality of raised members extending outward from the outer surface of said first tubular.

20 36. A method as claimed in claim 35, wherein said plurality of raised members define inserts filled into preformed apertures in the outer surface of said first tubular.

37. A method as claimed in claim 36, wherein said inserts are fabricated from a hardened alloy material.

25

38. A method as claimed in claim 36, wherein said inserts are fabricated from a ceramic material.

39. A method as claimed in any of claims 35 to 38, wherein said plurality of raised  
30 members are initially recessed at least partially within the wall of said tubular body, but

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then protrude from the outer surface of said tubular body upon expansion of said tubular body.

40. A method as claimed in claim 35, wherein said plurality of raised members  
5 defines a plurality of buttons having teeth.

41. A method as claimed in claim 34, wherein said gripping means defines a  
plurality of hardened tooth patterns added to the outer surface of the tubular body  
between said grooves.  
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42. A method as claimed in any of claims 27 to 41, wherein each of the first and the  
second tubulars is a string of casing.

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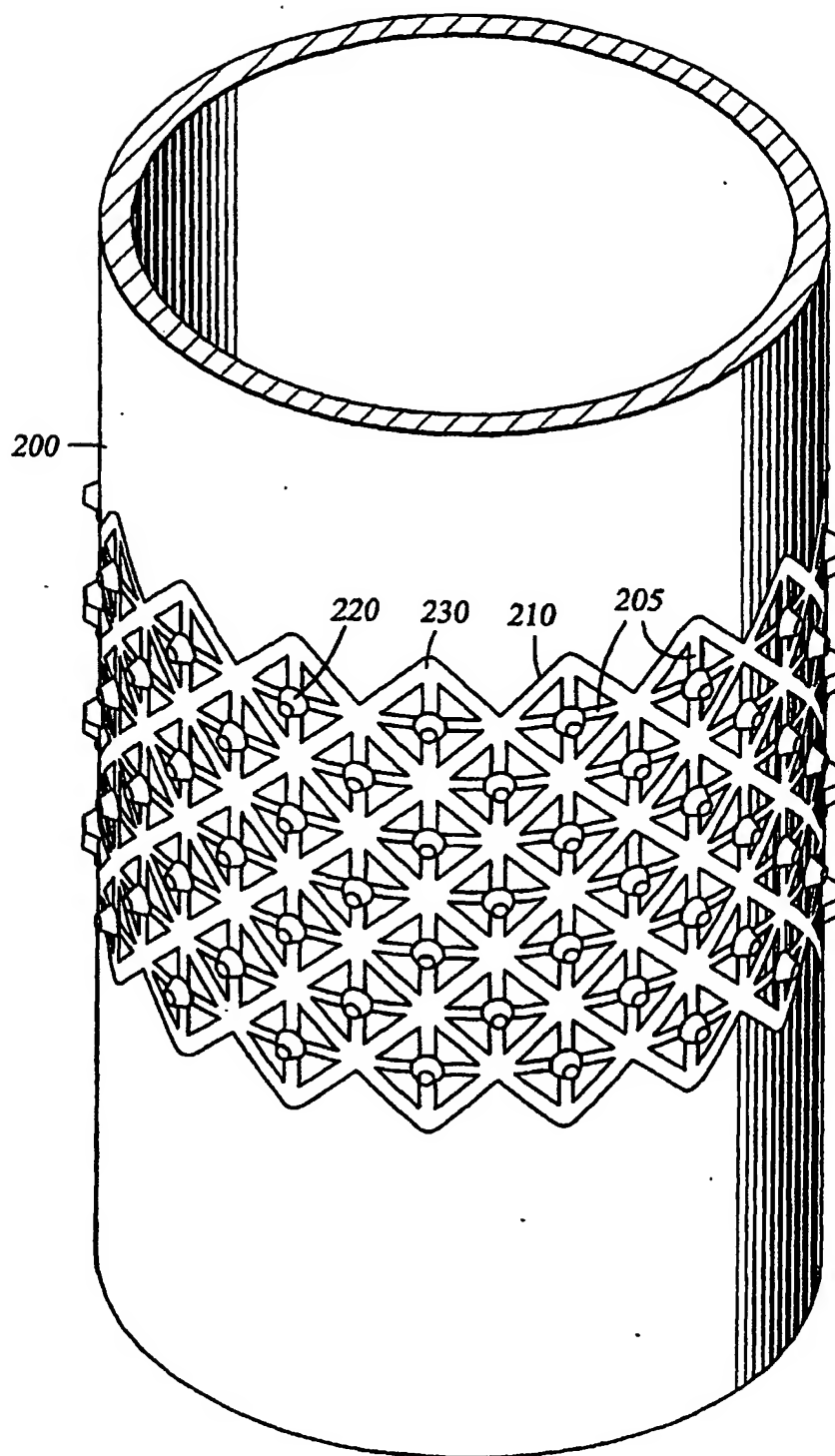


Fig. 1

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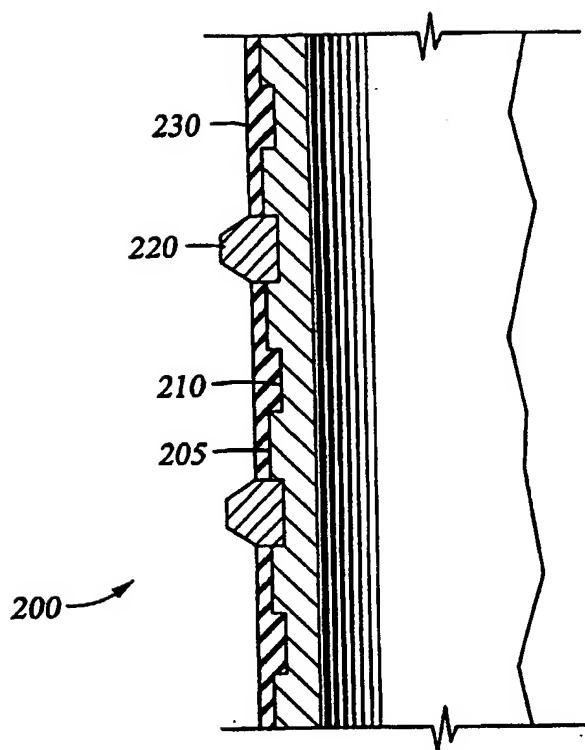


Fig. 2

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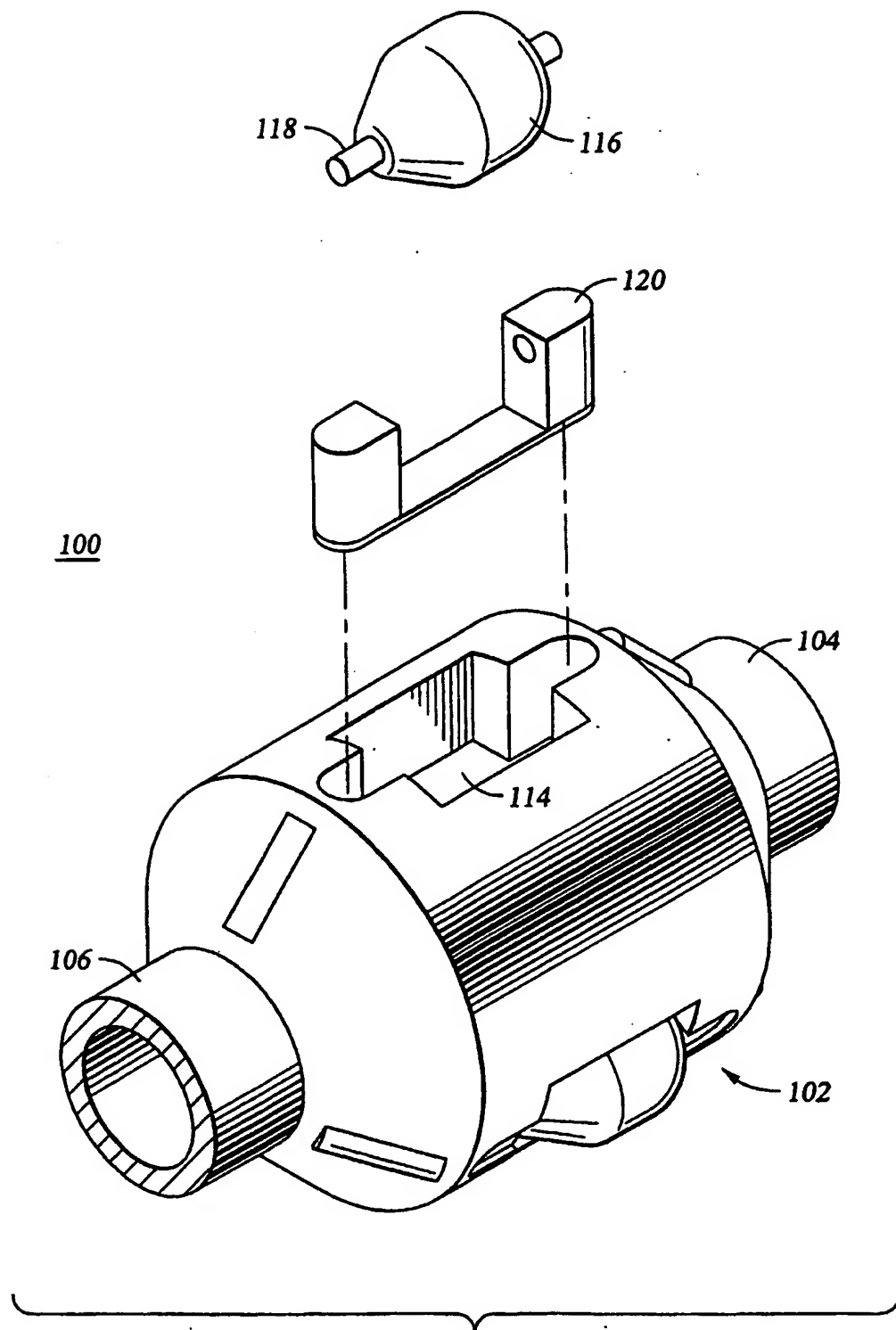


Fig. 3



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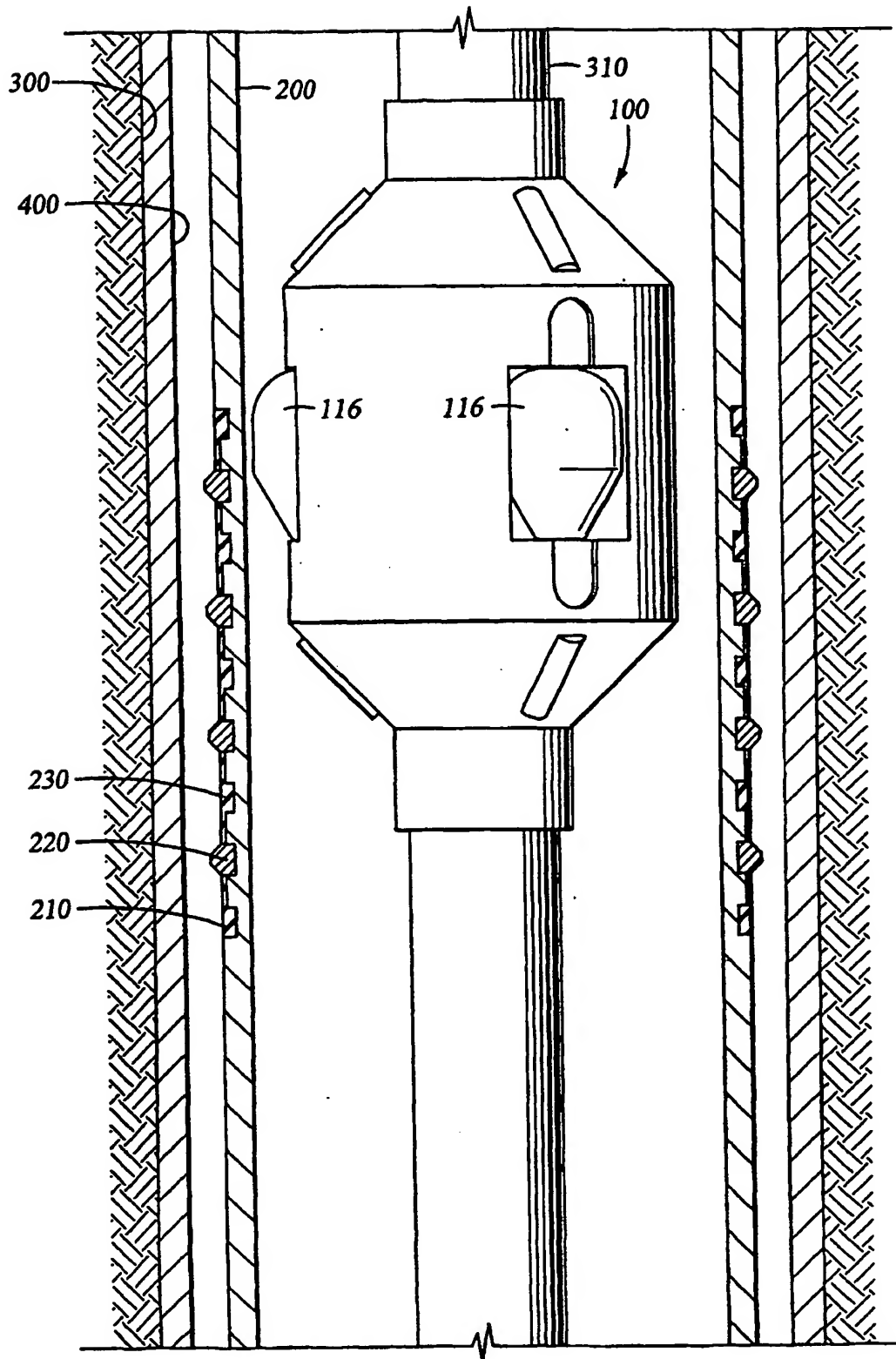
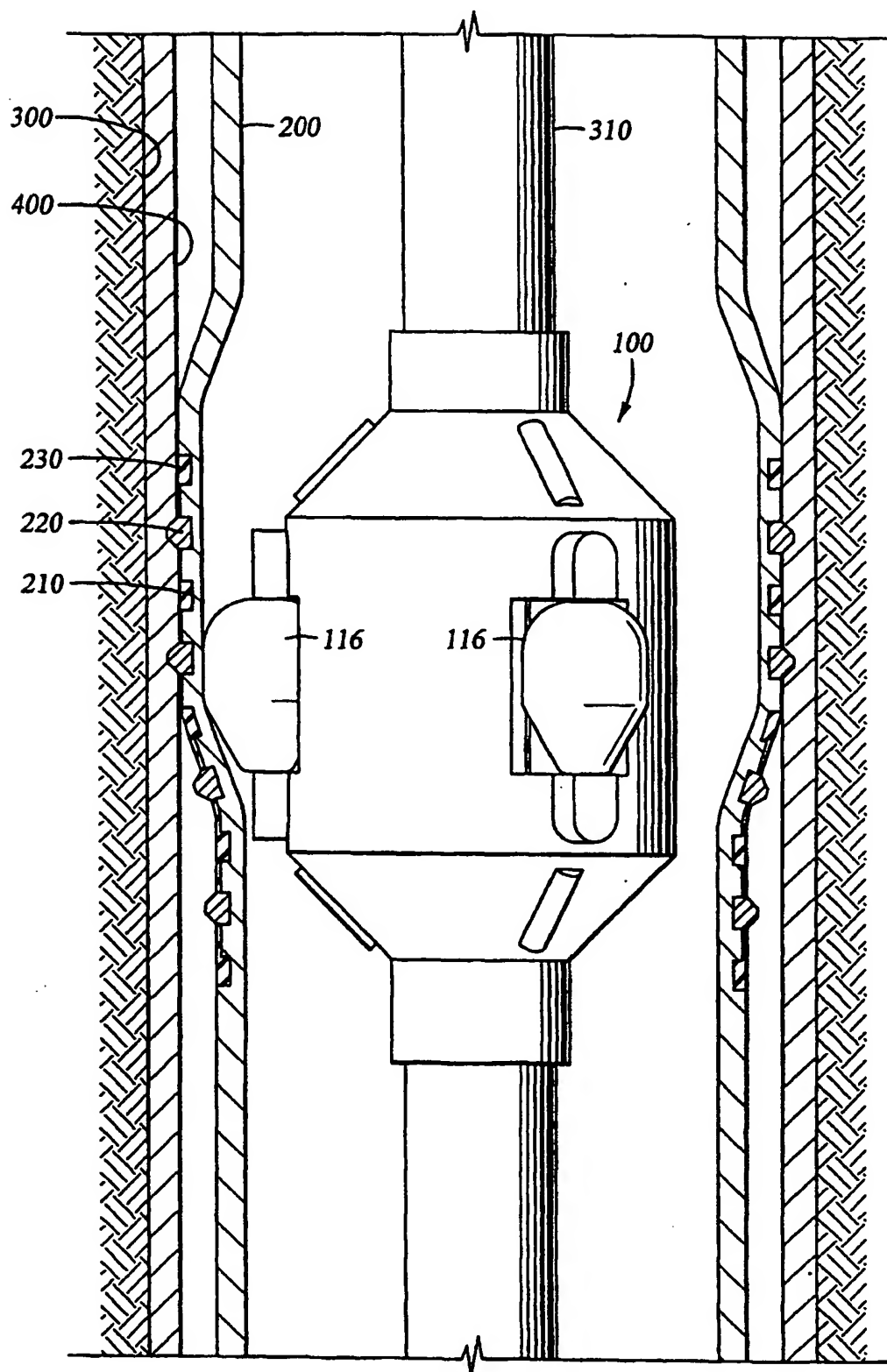


Fig. 4

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*Fig. 5*

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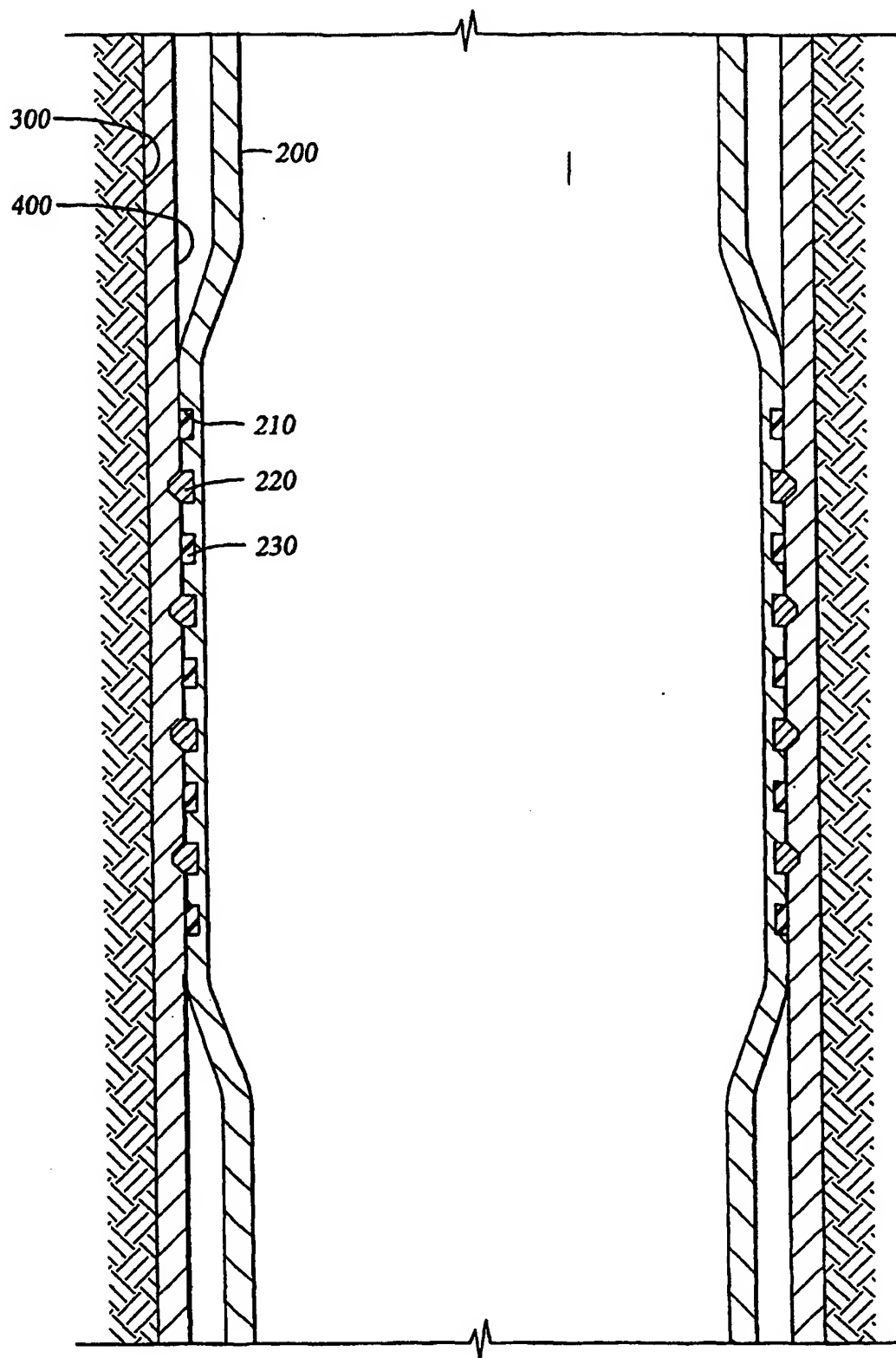


Fig. 6

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 02/03936

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Date of the actual completion of the international search

15 October 2002

Date of mailing of the international search report

24/10/2002

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